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(54) Method and apparatus for screening fibrous suspension

(57) A fiber suspension, such as in a pulp mill, is treated in a manner which minimizes both the investment and the operating costs associated with a screening plant. A single pump (114) has an outlet connected to a knotter (112) and primary (120) and secondary (126) screening stages, so that the pump provides substantially the sole motive force to the pulp, moving it through the knotter and screening stages. The knotter and screening stages are provided in a common housing with the coarse screen vertically above the screening stages, and the screening stages one above the other. A single motor may be provided to rotate rotatable elements associated with the knotter and screening stages. The coarse screen may be connected to a knot washer (116) external of the housing by a valved conduit less than two meters in length, and the secondary screening stage can be connected to a tertiary screening stage (128) exterior of the housing by a valved conduit less than two meters long. Rejects from the knot washer and secondary screening stage may be recycled to the pulp inlet, and the dilution water may be introduced where necessary.

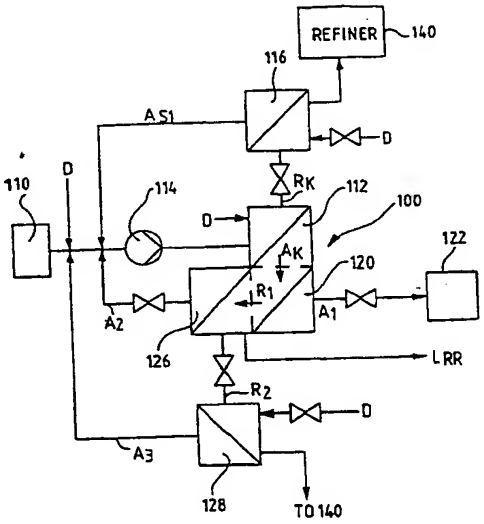

FIG. 2

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Description

[0001] The present invention relates to a fiber suspension treatment apparatus according to the preamble of claim 1. Moreover, the present invention relates to a method of screening cellulose pulp.

BACKGROUND AND SUMMARY OF THE INVENTION

[0002] In conventional pulp mills the facilities for screening of pulp require both high capital investment and have high operating costs. Typically different components in the screening plant are connected to each other by long pipes, each piece of apparatus being independent of the other. Usually a number of centrifugal pump are utilized for pumping the fiber suspension from one station to another to ensure continuous flow and treatment. Each piece of equipment is normally designed only for one purpose, and the layout of the screen room takes up significant floor space. Typical equipment that is utilized includes knotters, such as shown in U.S. Patent 4,927,529, knot washers such as shown in European published Patent Application 93890042, and pressure screens such as shown in U.S. Patents 4,634,521, 4,776,957, 4,915,822, 4,950,402, 5,000,842, 5,147,543, and 5,172,813.

[0003] This equipment may be utilized in the novel and advantageous apparatus and method according to the present invention.

[0004] One of the pieces of equipment described above, namely in U.S. Patent 4,634,521, removes light rejects from the pulp being treated. A cylindrical screen drum is provided which rotates a vertically disposed dome-shaped cylindrical rotor. The volume inside the rotor is operatively connected with the reject space between the screen cylinder and the rotor. When this equipment is dismantled the rotor is found to be filled with plastic and other lightweight and unwanted material, therefore a pipe is disposed inside the rotor to extend close to the top of the rotor to allow the rejects to flow into the pipe away from the rotor.

[0005] There are some patents that teach apparatus which performs a plurality of functions. For example, pressure screens are shown in U.S. Patents 3,677,402, 3,785,495, 3,865,243 and 3,898,157 which disclose two sorting stages disposed within the same housing. For example U.S. patent 3,677,402 discloses an apparatus including a stationary screen cylinder and a rotor rotating inside the screen cylinder. The rotor surface is provided with openings substantially larger than the openings of the screen cylinder. Additionally, the top portion of the rotor extend above the screen cylinder. As the pulp to be treated is introduced into the apparatus it is first divided into two fractions by means of the top portion of the rotor surface which thereby rejects the larger sized particles to be discharged from the apparatus. The accept portion of the fiber suspension flows inside the rotor from where it, due to centrifugal forces, flows back through the rotor surface towards the screen cylinder so that the accept portion flows through said screen surface outside thereof and the reject portion remains inside the screen surface to be discharged from the apparatus.

[0006] DE-A-39 17 151 discloses an apparatus for screening medium consistency pulp where the consistency of the pulp is from 6 to 15 %. The apparatus includes several screening stages within the same screen housing. However on column 2, line 60 to column 3, line 2, it has been taught that it is the rotor that makes the fiber suspension and the various fractions move in both axial and radial direction. The same teaching is given also on column 3, lines 47 - 52. In other words, it is the rotor of the screen which makes the pulp flow further within the rotor from one screening stage to another.

[0007] SE-A-431 571 discloses a screening arrangement where a pump is used for feeding fiber suspension to a screening device from where the reject fraction is further introduced into refiner. However, it is a fact that the structure of an ordinary refiner is such that the refiner has a feed screw upstream of the refiner plates for ensuring the necessary pressure for refining. In other words, the pressure of the pump does not have to feed the reject fraction through a refiner as the refiners always have a pressure generating means of their own.

[0008] Equipment is also known in which a screening unit is combined with a centrifugal cleaner.

[0009] By using some of the equipment as described above, the layout and investment costs of a screen room can be improved somewhat. However, typically such arrangements only eliminate one pump and one screen, meaning that there is still a need for a plurality of pumps with consumption of excessive floor space.

[0010] It is the object of the present invention to minimize the capital investment and operating costs for screening of pulp.

[0011] This object is solved by a fiber suspension treatment apparatus comprising the features of claim 1. Moreover, this object is solved by a method of screening cellulose pulp comprising the features of claim 17.

[0012] According to the present invention a fiber suspension treatment apparatus, and method of screening cellulose pulp, are provided which are extremely advantageous compared to the typical prior art as described above. The investment and operating costs of a screening plant utilizing the apparatus according to the invention can be only a fraction of what they are in the conventional art, yet there is no sacrifice in functionality.

[0013] According to the present invention the fiber suspension treatment apparatus comprises the following elements: A single pump having an inlet and an outlet. A coarse screen. A primary screening stage. A secondary screening stage; and the single pump outlet connected to the coarse screen and screening stages to provide substantially the sole motive force to a fiber suspension to move the fiber suspension through the

coarse screen and screening stages.

[0014] Preferably the coarse screen and screening stages are disposed within the same housing, and define a continuous pathway for fiber suspension within the housing extending from the coarse screen to the primary screening stage, and then to the secondary screening stage. The coarse screen rejects discharge is typically connected to a knot washer external of the housing, and the accepts of the knot washer are connected to the pump inlet. A recycle conduit is also typically provided from the secondary screening stage to the pump inlet, the recycle conduit having a length of less than two meters. In fact, essentially all of the conduits utilized in the practice of the invention have a length which is less than two meters, preferably less than 1 meter.

[0015] A tertiary screening stage may be connected to the rejects outlet with the accept outlet from the tertiary screening stage is connected to the pump inlet. A single motor may be provided for simultaneously powering the coarse screen and the screening stages, such as by being connectable to rotatable elements of the coarse screen and screening stages. The coarse screen is typically located immediately vertically above the first screening stage, which in turn is immediately above the second screening stage. Valves are typically provided in the conduit extending from the common housing to external equipment such as the knot washer and tertiary screening stage.

[0016] According to the present invention the fiber suspension treatment apparatus may comprise the following elements: A housing. A coarse screen disposed in the housing and having a first rotatable element. A primary screening stage disposed in the housing and having a second rotatable element. A secondary screening stage disposed in the housing and having a third rotatable element. A first accepts discharge leading from the coarse screen directly to the primary screening stage, and a first rejects discharge. A second accepts discharge leading from the primary screening stage directly to the secondary screening stage, and a second rejects discharge. And, a third accepts discharge from the secondary screening stage, and a third rejects discharge.

[0017] The rotatable elements are typically disposed in a straight line arrangement and are driven by a common drive, preferably a single motor mounted on a portion of the housing or disposed on a top portion of the housing and connected to the rotatable elements by drive belts. The first rejects discharge is connected to a knot washer exterior of the housing and the third rejects discharge is connected to a tertiary screening stage exterior of the housing, both by valved conduits having a length less than two meters. The primary screening stage may comprise first, second and third screening stages, the accepts from one stage leading to the next.

[0018] According to the present invention the method of screening cellulose pulp comprises the following steps: (a) pressurizing cellulose pulp to a first pressure which is higher than a discharge pressure for the pulp; (b) under substantially the sole influence of the first pressure, without repressurizing, effecting deknotting, primary screening, and secondary screening of the pulp in knotting, primary screening, and secondary screening sequential stages; and (c) positioning the stages so that each stage is less than two meters from the next stage.

[0019] There might also be the further step of discharging rejects from the knotting and passing the rejects to a knot washer substantially solely under the influence of the first pressure, without repressurizing. Also there may be the further step of discharging rejects from the primary and secondary screening stages substantially solely under the influence of the first pressure, without repressurization. Rejects may be recirculated from the secondary screening stage and the accepts from the knot washer, back to the deknotting stage substantially solely under the influence of the first pressure. Dilution liquid is also typically fed into the pulp and at least one of the deknotting and primary and secondary screening stages, and typically all of them.

[0020] The object and the features of the present invention will become clear from an inspection of the detailed description of the invention, and from the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021]

FIGURE 1 is a schematic illustration of an exemplary prior art system for treating fiber suspension in a screening room of a pulp mill;

FIGURE 2 is a schematic illustration of the layout of exemplary screening apparatus according to the present invention which takes the place of the apparatus in FIGURE 1;

FIGURE 3 is a side cross-sectional schematic view of a first embodiment of exemplary knotting and screening apparatus according to the present invention;

FIGURE 4 is an enlarged, detailed view of the interface between the knotting and the primary screening stages of the apparatus of FIGURE 3;

FIGURE 5 is a view like that of FIGURE 4 only of an alternative embodiment of apparatus according to the invention;

FIGURE 6 is a schematic side cross-sectional view of merely the knotter section of exemplary apparatus like that of FIGURE 3;

FIGURE 7 is a view like that of FIGURE 6 for an alternative embodiment, and FIGURE 7a is an enlarged view of a portion of the apparatus of FIGURE 7;

FIGURE 8a is a view like that of FIGURE 7 for yet another embodiment according to the pres nt

invention, and

FIGURES 8b and 8c are detail side views, partly in cross-section and partly in elevation, of cooperation between components of the knotter of FIGURE 8a;

FIGURE 9 is a top plan view of exemplary apparatus shown only schematically in FIGURE 2; and

FIGURE 10 is a schematic illustration like that of FIGURE 2 only for a modified form of apparatus according to the invention.

DETAILED DESCRIPTION OF THE DRAWINGS

[0022] FIGURE 1 schematically illustrates a known prior art equipment layout for treating fiber suspensions in a screening room of a pulp mill. The pulp to be treated is introduced into the screening from the preceding treatment stage, for instance, a storage tower 10. The fiber suspension may also be brought directly from the preceding treatment stage without any storage therebetween. The pulp is first introduced into a coarse screen (knotter) 12, such as shown in U.S. patent 4,927,529, by means of a pump 14. The rejects from the knotter 12 are introduced into a knot washer 16, shown for instance in an EP patent application 93890042. The goal of the pulp treatment in the knot washer 16 is to wash finer fiber material attached to the knots and shives out and to recycle it for further treatment. In FIGURE 1 the accepted finer fiber material is brought back in front of the pump 14 to be re-introduced into the knotter 12. Rejected knots, etc., are discharged from the stocker 16 to be disposed of, for instance by combustion.

[0023] The accept fraction of the knotter 12 is pumped, preferably by means of a centrifugal pump 18, to a primary screen 20 which is preferably a pressure screen like the ones described for instance in U.S. patents 4,634,521, 5,000,842 and 5,172,813. The accepts of the primary screen 20 are most often introduced into a thickener 22. The reject fraction of the primary screen 20 is pumped with a centrifugal pump 24 to a secondary screen 26, the screening apparatus being in principle similar to the primary screen 20. The accepts of the secondary screen 26 are fed upstream of the primary screen 20, preferably in front of the pump 18, and the rejects of the secondary screen 26 are oftentimes introduced to a tertiary screen 28.

[0024] The accepts of the tertiary screen 28 are introduced into the inlet of the secondary screen 26, preferably in front of the pump 24. The rejects of the tertiary screen 28 are discharged out of the screening room, e.g., to be burned.

[0025] Often the accepts of the knotter 12 and the rejects from the primary screen 20 have been thickened so that they must be diluted prior to introduction into the next treatment stage. Therefore dilution liquid tanks 30, 32 respectively, are provided at the inlets of the pumps 18, 24, respectively. Often the dilution liquid is received from the thickener 22, i.e., the filtrate thereof or from the fourdrinier of a paper machine.

[0026] The prior art screening room in accordance with FIGURE 1 includes three centrifugal pumps 14, 18 and 24, four (preferably pressurized) screens 12, 20, 26 and 28, and a stocker 16, each piece of equipment having its own electric drive unit, i.e., eight electric motors and five reduction gear assemblies (for the screening devices). Additionally, the primary and the secondary screening circuits are provided with tanks 30 and 32 for dilution liquid. Also all the knotter 12 and the primary and the secondary screen units 20, 22 need valves 34, 36, 38, 40, 42, 44 for regulating the flow in both the accept and the reject lines. Also due to the numerous separately mounted structures piping from one unit to another unit is long, and for practical reasons the apparatus is installed such that the knotter, stocker and the pressure screens are located one story higher than the storage tower 10 dilution liquid tanks 30, 32 and pumps 14, 18 and 24, whereby the pulp travels between the ground floor and the second floor of the screening room.

[0027] FIGURE 2 schematically illustrates the layout of a screening room, or a screening plant, in accordance with a first embodiment of the present invention. In FIGURES 2 through 9 components functionally comparable to those in the prior art construction of FIGURE 1 are shown by the same reference number only preceded by "1."

[0028] The pulp (e.g., at a consistency of ½-10%, typically about 1-3%) is introduced into this novel screening apparatus 100 by means of a main (and typically sole) centrifugal feed pump 114 which receives fiber suspension from the preceding treatment stage or a storage tower 110. The pulp enters the knotter section 112 of the unit 100 and is divided into two fractions of which the reject fraction RK is discharged to the stocker 116 and the accept fraction AK enters the primary screening section 120. In the knot washer 116 the reject fraction RK is divided into two fractions by washing the useable fibers out of the knot stock so that the accepted fiber material AS1 is recycled to the suction side (inlet) of the main feed pump 114, with rejects to refiner 140, or for burning.

[0029] In the primary screening section 120 the fiber suspension, or the accept fraction of the knotter section 112, is again divided into two fractions of which the accept fraction A1 is discharged from the screening unit 100 and for instance, introduced into a thickener 22, whereas the reject fraction R1 flows to the secondary screening section 126.

[0030] In the secondary screening section 126 the reject fraction R1 is still divided into two fractions of which the accept fraction A2 is recycled preferably to the suction side of the main pump 114 and the reject fraction R2 is discharged to the tertiary screening apparatus 128 where the rejects from R2 are divided into two fractions. The accept fraction A3 from the tertiary screening apparatus 128 is recycled to the suction side of the main feed pump 114, while rejects R3 are disposed of (e.g., burned) or fed to refiner 140.

[0031] A sufficient number of dilution liquid connections D are provided in the system. FIGURE 2 shows dilution liquid connections D for feeding dilution liquid to the knotter section 112, to the knot washer section 116, to the tertiary screening apparatus 128, and to the inlet of the main feed pump 114. Also the apparatus may be provided with light rejects removal as shown by LRR.

[0032] FIGURE 3 shows an embodiment of a screening unit of the present invention which includes three sections (as illustrated only schematically in FIGURE 2), i.e., the knotter section 112, the primary screening section 120 and the secondary screening section 126. In the embodiment shown in FIGURE 3 the sections are disposed vertically one above the other in such a way that the knotter section 112 is at the top of the interior of a common housing 150 for the apparatus, the primary screening section 120 is in the middle, and the secondary screening section 126 at the bottom. The vertically disposed cylindrical main housing 150 has a top cover 152, and a dome shaped rotor 154 is disposed inside the housing 150 and connected by means of a shaft 156 to drive means (e.g., an electric motor, not shown). A screen cylinder, preferably formed of sections respectively, is disposed surrounding the rotor 154. The rotor 154 is a common, in-line, rotatable element for all of sections 112, 120 and 126.

[0033] The housing 150 is further provided with an inlet 160 for the stock to be treated, an outlet 162 for the rejects RK of the knotter section 112, an outlet 164 for the accepts A of the primary screening section 120, an outlet 166 for the accepts of the secondary screening section 126, and an outlet 168 for the rejects of the secondary screening section 126. The knotter section 112 includes, in accordance with this embodiment, a rotating perforated knotter cylinder 170 which is attached to the top of the rotor 154 and a plurality of stationary blades 172 attached to the top cover 152 of the housing 150. The stationary blades 172 and the perforated knotter cylinder 170 function together in a manner known per se. The knotter cylinder 170 is sealed against the screen cylinder 158 so that no fresh untreated stock is able to flow between the rotor 154 and the screen cylinder 158. The accepts fraction of the knotter section 112 firstly flows radially inwardly through the openings of the cylinder 170 and then downwardly onto the top of the rotor 154 and therealong radially outwardly between the bottom circumference of the knotter cylinder 170 and the top of the rotor 154 directly into the primary screening volume 174 between the rotor 154 and the screen cylinder upper section 158.

[0034] Rotation of the rotor 154 subjects the stock to circumferential forces tending to make the stock rotate in a circumferential direction. In a manner known per se, the accept fraction A1 of the primary screening section 120 flows through the openings in the screen cylinder 158 and enters the accept volume and flows from there to the accept outlet 164. The accepts A1 are further introduced, for instance, to a dewatering device such as a drum thickener. The reject fraction R1, i.e., the fraction of the stock which has not passed through the screen cylinder upper section 158, flows gradually downwardly and enters the secondary screening section 126 and its screening volume 176. The object of the secondary screening section 126 is to treat the reject fraction R1 in such a way that the fibers attached to heavier coarser particles are loosened therefrom and the fiber flocs break-up so that the major portion of the acceptable fibers of the reject fraction can be recovered. The accept fraction A2 which has passed the lower screen cylinder section 159 enters the secondary accept volume and is discharged via the outlet 166, and is preferably recycled to the screening unit 100 in the manner shown in FIGURE 2.

[0035] The reject fraction RK of the knotter section 112 is discharged via outlet 162 to a stocker 116 which may, in principle, be like the one shown in EP Patent Application 93890042. The accepts AS1 of the knot washer 116 are discharged through outlet 182 and the rejects RS1 through outlet 184. Preferably the accept fraction AS1 received from the stocker outlet 182 is returned back to the fiber suspension flow into the pump 114 inlet of the screening unit 100. However, it is possible to use this fraction for other purposes too. The rejection fraction RS1 of the stocker 116 received from outlet 184 may be transported to a refiner [140 in FIGURE 2] for refining, or discharged from the entire mill to be, for instance, incinerated.

[0036] The rejects R2 from the secondary screening section 126 are discharged, as explained earlier, via outlet 168 to the tertiary screening apparatus 128. Apparatus 126 is -- in principle -- a small sized stocker, like the one shown and described in EP Patent Application 93890042, though many different types of apparatus may be used for the same purpose. The accepts A3 from the tertiary screening apparatus 128 are discharged from outlet 186 and, preferably, transported to the inlet of the main feed pump 114 of the screening unit 100. The rejects R3 of the tertiary screening unit 128 are discharged from outlet 188 to be either refined (e.g., in refiner 140), incinerated, or used in some other way.

[0037] FIGURE 3 also shows other optional equipment disposed in the screening unit housing 150. The inside of the rotor 154 is provided with two ducts 190 and 192, marked LRR and D, respectively. Duct 190 is used for removing light rejects from the inside of the rotor 154. If and when the stock to be treated includes light rejectable material like plastic particles, styrofoam etc., they tend to collect inside the rotor 154 so that the dome portion of the rotor 154 becomes filled with the light particles since they float on the surface of the fiber suspension inside the rotor 154. The operating principles of this structure are described in U.S. Patent 4,634,521. The duct 192, is used for feeding dilution liquid D to the dome portion of the rotor 154 to enhance the separation of light rejects. The dilution liquid generally washes the fiber material out of the light rejectable

material so that less fiber material is discharged along with the light rejects via duct 190. The use of the dilution liquid is described in more detail in Japanese Patent Application 1730405, the disclosure of which is incorporated by reference herein.

[0038] In accordance with a preferred embodiment of the invention the openings in the knotter cylinder 170 are substantially round, having a diameter of about 6 to 12 mm. The openings in the screen cylinder in the primary screening section 120 may be either round holes or elongated slots. If holes are provided, the diameter thereof is about 1.0 - 1.6 mm, and the diameters of the holes in the secondary screening section 126 are on the order of about 1.0 - 2.0 mm. If slots are provided the width thereof is about 0.20 - 0.40 mm, while the openings in the secondary screening section 126 are substantially round holes having a diameter of about 1.0 - 1.6 mm.

[0039] FIGURE 4 shows an enlarged view of the knotter section 112 of the apparatus of FIGURE 3. As already explained in connection with FIGURE 3 the knotter section 112 of the screening unit consists of a knotter cylinder 170 attached to the rotor 154 and stationary blades 172 disposed inside the knotter cylinder 170 and attached to the top cover 152 of the screening unit 100. Onto the inside surface of the top cover 152 there is attached an annular ring 194 coaxial with the rotor 154. The blades 172 are attached at their upper ends to the ring 194 and at their lower ends to a cylindrical support ring 196 so that the distance between the blades 172 and the knotter cylinder 170 remains substantially the same throughout the whole length of the blades 172. The knotter cylinder 170 has two sealing members; an upper one 198 and a lower one 200. The upper sealing member 198 is, in this embodiment, a radially outwardly projecting flange facing corresponding sealing members 202 of the annular ring 194. The gap between the sealing members 198 and 202 is maintained small enough to substantially prevent leakage therethrough. The lower sealing member 200 is formed of an outwardly extending conical flange portion and a cylindrical flange portion at the outer end of the conical portion.

[0040] The inner surface of the cylindrical flange portion faces a sealing member 204 which is attached between the screen cylinder 158 and a flange 206 extending radially inwardly of the housing 150 of the screening unit 100. The gap between the sealing members 200 and 204 is maintained small enough to substantially prevent leakage therethrough. The gap between the moving 200 and the stationary 204 sealing members may be provided with means for pumping the medium tending to flow into the gap away from the gap such means being disclosed in FI patent 79304, the disclosure of which is incorporated by reference herein.

[0041] The knotter cylinder 170 is attached to the top of the rotor 154 by means of legs 208 in such a manner that a wide enough gap 197 is provided between the conical flange 200 and the top of the rotor 154 to allow the accept fraction of the knotter to flow therethrough into the primary screening volume 174. As it is important for the function of the rotor 154 as well as the knotter cylinder 170 to have a certain circumferential speed, it is possible to adjust the corresponding diameters so that the speeds are the ones desired.

[0042] It is to be noted, however, that the details described above are exemplary only, and the apparatus may be constructed in many different ways. Therefore it is also possible that the gaps between the sealing members may well be axial instead of the radial gaps shown in FIGURE 4. Also it is possible that no outwardly extending conical portion is provided where a high circumferential speed of the knotter cylinder is desired, so that the diameter of the knotter cylinder 170 may even be larger than the diameter of the rotor 154. Further, the sealing member 204 does not need to be part of a member between the screen cylinder 158 and the flange 206; it may, for instance, be a part of the flange 206, a part of the screen cylinder 158, or an entirely independent member attached on the housing 150 or on the flange 206.

[0043] In FIGURE 5 there is shown another preferred embodiment of the invention and especially of the knotter section 112' thereof. As in the FIGURE 4 embodiment, the section 112' comprises a rotating knotter cylinder 170' and a plurality of stationary blades 172'. However, in accordance with this embodiment the knotter cylinder 170' is not attached to the rotor 154' but rather is mounted to be independently driven through the top cover 152' of the screening unit 100. The knotter cylinder 170' is attached by means of a radially inwardly extending flange (or arms) 210 and a radially outwardly extending flange 212 on a shaft 214 which is attached through the top cover 152' by means of bearings and seals (not shown).

[0044] The shaft 214 is preferably driven by means of an electric motor 216 through, for instance, V-belts 218 so that the desired circumferential speed of the knotter cylinder 170' is achieved by defining the correct diameters of pulleys 220 and 222.

[0045] The stationary blades 172' are attached to the radial flange 206' extending inwardly from the housing 150 or in some other appropriate way. In the embodiment of FIGURE 5 the base 224 of the blades 172' is used for fastening the screen cylinder 170' in place. In other words, the base 224 has a conical portion 226 facing a corresponding conical portion of the upper end of the screen cylinder. The inner edge of the flange 206' is coaxial with the rotor 154' and of equal diameter with the cylindrical portion 228 of the base 224 so that when the bolts 230 are tightened the base 224 with blades 172' moves axially downwardly and centers the screen cylinder 158 in place. The base 224 has also a cylindrical surface 232 above the conical portion 226 to provide sealing with a similarly cylindrical portion 234 of the knotter drum 170'. The purpose of this sealing is to pre-

vent untreated material from entering the primary screening volume 174' between the screen cylinder 158 and the rotor 154'.

[0046] In FIGURE 6 there is illustrated a further embodiment of the knotter section of the apparatus of the invention. The shaft of the rotor 154 is provided with outwardly projecting arms 240 spaced from the top of the rotor 154. The arms 240 carry a plurality of concentrically mounted circular rings 242 so that the spacing between the rings 242 define the knotter opening. The outer ends of the arms 240 are provided with a cylindrical sealing member for cooperation with, for instance, the upper end of the screen cylinder 158. The purpose of the knotter is to prevent knots, stones or metal particles from entering the primary screening section of the screening unit 100.

[0047] In FIGURE 7 there is shown a still further embodiment of the knotter section of the invention. Basically the operational principle of the knotter of FIGURE 7 is the same as the one of the knotter of FIGURE 6. However, in the embodiment of FIGURE 7 (see FIGURE 7a) the arms 236 extend substantially vertically and are attached to the top of the rotor 154, preferably close to the outer circumference of the rotor 154. The arms 236 are provided with a plurality of adjacent annular radial rings or like members mounted in a substantially radial plane so that they form knotter openings therebetween. The accepted fraction flows from the top of the rotor 154 into the primary screening section 120 as shown by arrow F. In accordance with a preferred embodiment the lowermost plate forms a sealing between the upper edge of the screen cylinder or some other appropriate member in order to prevent undesirable material from entering the primary screening volume. Also the uppermost member may be a solid plate forming a cover for the knotter section. Another way to prevent the untreated pulp from entering inside the knotter "cylinder" is to extend the arms 236 up to the close proximity of the top cover 152 of the housing and provide the upper ends of the arms with a ring forming a sealing between the top cover and the knotter "cylinder." A preferred way of providing such a seal is shown in FIGURE 4.

[0048] In FIGURES 8a, 8b and 8c there is illustrated yet another preferred embodiment of the invention and especially of the knotter section thereof. FIGURE 8a shows the general concept of the knotter section. It consists of a plurality of outwardly extending arms 240 or like members which are attached on the same shaft with the rotor 154 preferably at a distance above the top of the rotor 154. The arms 240 are provided with adjacent coaxial annular rings 242 which provide a radial space therebetween. There are a plurality of stationary arms 244 or like members attached above the arms 240, for instance, like the base 224 of the wings 172' in FIGURE 5. The stationary arms 244 are provided with a number of annular coaxial rings 246 leaving a radial space therebetween in such a manner that rings 246 fit into the spaces between rings 242 and vice versa. In the way described above a knotter screen has been developed where the screen is formed of a number of adjacent annular screening slots. The purpose of the knotter screen is both to prevent large impurities from entering the primary screening section 120 below the knotter, and to create turbulence for breaking up large fiber flocs so that as much desirable fiber as possible is introduced into the primary screening section 120. FIGURES 8b and 8c show some alternatives for the cross-sectional configuration of the annular rings. In FIGURE 8b the cross-section of the rings is triangular and in FIGURE 8c rectangular.

[0049] FIGURE 9 shows the layout of a preferred embodiment of the apparatus of the invention. The layout corresponds to the one shown in FIGURE 2 but FIGURE 4 describes the mutual location of the different apparatus. In the center of the arrangement is the screening unit 100 to which the fiber suspension to be treated is supplied by the main feed pump 114. By means of a correct design of the apparatus involved and correct positioning with respect to each other it is possible to connect pump 114 to screening unit 100 with a very short pipe (less than two meters long, e.g., less than one meter), or with no additional piping at all. In other words, in accordance with a preferred embodiment the outlet, or pressure flange 159, of the sole pump 114 is directly attached to the inlet flange 160 of the screening unit 100. If this is compared to the prior art system of FIGURE 1, where the main feed pump 14 is on the lower floor of the building and connected to the screen 12 by means of a vertical pipe having a length of about 10 meters, it is easy to see the difference. Accordingly the screening unit 100 is directly connected to the knot washer 116 and to the tertiary screening apparatus 128 with its appropriate conduits 162 and 168, preferably flange to flange connections without any additional conduits. The only conduits needed in the arrangement are those connecting the main screening unit 100, the knot washer 116, and the tertiary screening apparatus 128, to the suction side of the main feed pump 114. However, the length of these conduits may be optimized such that the total length of the conduits is negligible, (i.e., less than two meters, preferably less than one meter). All the apparatus is thus easily mounted on the same story of an enclosed building.

[0050] FIGURE 10 schematically illustrates yet another preferred embodiment of the present invention. The basic arrangement is the same as shown in FIGURE 2, accordingly, the same reference numerals are used herein, too.

[0051] The apparatus of FIGURE 10 is provided with two additional screening stages arranged directly at the accepts outlet of the primary screening section 120, in other words, the additional screening stages are attached to the accepts outlet 164 of FIGURE 3. The additional two screening stages are the second screening stage 260 and the third screening stage 280, all part

of the primary stage 120. In accordance with the embodiment of FIGURE 10 the accept fraction of the second screening stage 260 is conveyed to thickener 122, or used in the next treatment step. The reject fraction flows to the third screening stage 280 where it is divided into two fractions; an accepts fraction which is preferably returned to the inlet of the sole pump 114, and a reject fraction which is introduced with the reject fraction of the secondary screening stage 126 into a tertiary screening stage 128.

[0052] The apparatus performing the second and third screening stages 260 and 280 may, in principle be like the one shown in FIGURE 3 except that the knotter section thereof is deleted. The apparatus may be provided with light rejects removal LRR as discussed earlier in connection with FIGURE 3.

[0053] In accordance with a preferred embodiment the screen cylinders in the knotter section 112, the primary screening section 120, and the third screening stage 128 are provided with round holes, whereas in the second screening stage 126 the screen cylinder is provided with narrow slots.

[0054] The screen cylinders used in the knotter section 112 and in the two following screening sections 120, 126 may be of different types. The knotter cylinder is either a smooth screen cylinder or a contoured screen cylinder having ridges between the rows of openings. Both the contoured and smooth screen cylinders may be provided with either round holes, slots or combinations thereof. The cylinders in sections 120, 126 are preferably contoured.

[0055] In both the FIGURES 2 and 10 embodiments, the pump 114 pressurizes the cellulose pulp to a first pressure (which is higher than a discharge pressure for the pulp) so that under substantially the sole influence of the first pressure, without repressurizing, deknotting, primary screening, and secondary screening of the pulp take place in the knotting 112, primary screening 120, and secondary screening 126 sequential stages. The stages are positioned so that each stage is less than two meters from the next stage, preferably in a common housing as already described. Dilution liquid is fed into the pulp in at least one of the stages, and where needed.

[0056] It will thus be seen and according to the present invention an advantageous apparatus and method for effecting screening of cellulose pulp and like fiber suspensions is provided. While the invention has been herein shown and described and whereas presently conceived to be the most practical and preferred embodiment thereof it will be apparent to those of ordinary skill in the art the many modifications may be made thereof within the scope of the invention, which scope is to be accorded the broadest interpretation of the appended claims so as to encompass all equivalent structures and processes.

Claims

1. A fiber suspension treatment apparatus (100) having a pump (114) with an inlet and an outlet; a coarse screen (112, 112'); a primary screening stage (120); and a secondary screening stage (126),
characterized in that
said pump (114) outlet is connected to said coarse screen (112, 112') and screening stages (120, 126) to provide substantially the sole motive force to a fiber suspension to move the fiber suspension through said coarse screen (112, 112') and screening stages (120, 126).

2. Apparatus as recited in claim 1, characterized in that said coarse screen (112, 112') and screening stages (120, 126) are disposed within a same housing (150) and there is a continuous pathway for fiber suspension within said housing (150) extending from said coarse screen (112, 112') to said primary screening stage (120), and then to said secondary screening stage (126).

3. Apparatus as recited in claim 2, characterized in that said coarse screen (112, 112') includes a rejects discharge (162), and that a knot washer (116) connected to said rejects discharge (162); said knot washer (116) including an accepts outlet (182), and said knot washer (116) accepts outlet (182) connected to said pump inlet.

4. Apparatus as recited in claim 3, characterized in that a recycle conduit A_2 from said secondary screening stage (126) to said pump inlet, said recycle conduit A_2 less than two meters in length.

5. Apparatus as recited in claim 4, characterized in that said secondary screening stage (126) includes a rejects outlet (168); and that a tertiary screening stage (128), and a second conduit R_2 connecting said secondary stage rejects outlet (168) to said tertiary screening stage (128), said second conduit having a length less than two meters.

6. Apparatus as recited in claim 5, characterized in that said tertiary screening stage (128) includes an accepts outlet (186); said tertiary screening stage accepts outlet (168) connected to said pump inlet by a third conduit A_3 which has a length of less than two meters.

7. Apparatus as recited in claim 2, characterized in that an accepts outlet (164) from said primary screening stage (120), and that at least one additional screening stage (122) having an inlet positioned less than two meters from said accepts outlet (164) and connected to said accepts outlet

(164).

8. Apparatus as recited in claim 1, characterized by a single motor for simultaneously powering said coarse screen (112, 112') and screening stage (120, 126).

9. Apparatus as recited in claim 8 characterized in that said single motor simultaneously rotates rotatable elements of said coarse screen (112, 112')and screening stages (120, 126).

10. Apparatus as recited in claim 9, characterized in that said coarse screen (112, 112') is located immediately vertically above said first screening stage (120) , and said first screening stage (120) is immediately above said second screening stage (126).

11. Apparatus as recited in claim 1, characterized in that said coarse screen (112, 112') is located immediately vertically above first screening stage (120), and said first screening stage (120) is immediately above said second screening stage (126), and that dilution liquid conduits D connected to at least one of said coarse screen (112, 112') and screening stages (120, 126); and that all of said pump (114), coarse screen (112, 112'), and screening stages (120, 126) are on the same story of an enclosed building.

12. Apparatus as recited in claim 5, characterized in that a first valve in said recycle conduit R_K and a second valve in said second conduit R_2.

13. Apparatus as recited in claim 12, characterized in that a third conduit having a length of less than two meters connecting said knot washer to said coarse screen rejects discharge, and a third valve in said third conduit.

14. Apparatus as recited in claim 10, characterized in that said coarse screen (112, 112') and screening stages (120, 126) are in a common housing (150), and that said single motor (216) is mounted on a top portion of said common housing (150) and is connected to said rotatable elements by a drive element (218).

15. Apparatus as recited in claim 14, characterized in that said drive element (218) comprises a plurality of drive belts.

16. Apparatus as recited in claim 1, characterized in that dilution liquid conduits D connected to at least one of said coarse screen (112, 112') and screening stages (120, 126); and that all of said pump (114), coarse screen (112, 112'), and screening stages (120, 126) are on the same story of an enclosed building.

17. A method of screening cellulose pulp, characterized in the steps of:

(a) pressurizing cellulose pulp to a first pressure which is higher than a discharge pressure for the pulp;

(b) under substantially the sole influence of the first pressure, without repressurizing, effecting deknotting, primary screening, and secondary screening of the pulp in knotting (112, 112'), primary screening (120), and secondary screening sequential stages (126); and

(c) positioning the stages so that each stage is less than two meters from the next stage.

18. A method as recited in claim 17, characterized in the further step of discharging rejects from the knotting stage (112, 112') and passing the rejects from the knotting stage through a knot washer (116) substantially solely under the influence of the first pressure, without repressurizing.

19. A method as recited in claim 18, characterized in the further steps of discharging accepts from the primary (120) and second screening stages (126) substantially solely under the influence of the first pressure, without repressurizing.

20. A method as recited in claim 19, characterized in the further step of recirculating rejects from the second screening stage (126) back to deknotting stage (112, 112') substantially solely under the influence of the first pressure.

21. A method as recited in claim 17, characterized in that step (c) is practiced by disposing the deknotting (112, 112') and primary (120) and second screening stages (126) in a common housing, pulp from one stage directly immediately passing to the next stage.

22. A method as recited in claim 21, characterized in that step (c) is further practiced by disposing the stages one atop the other, and that deknotting (112, 112') and primary and second screening operations in the deknotting (112, 112') and primary (120) and secondary screening stages (126) are practiced by effecting rotation of a common rotatable element extending between the deknotting (112, 112') and primary (120) and second screening stages (126).

23. A method as recited in claim 17, characterized in the further step of feeding dilution liquid into the pulp in at least one of the deknotting (112, 112') and

primary (120) and secondary screening stages (126).

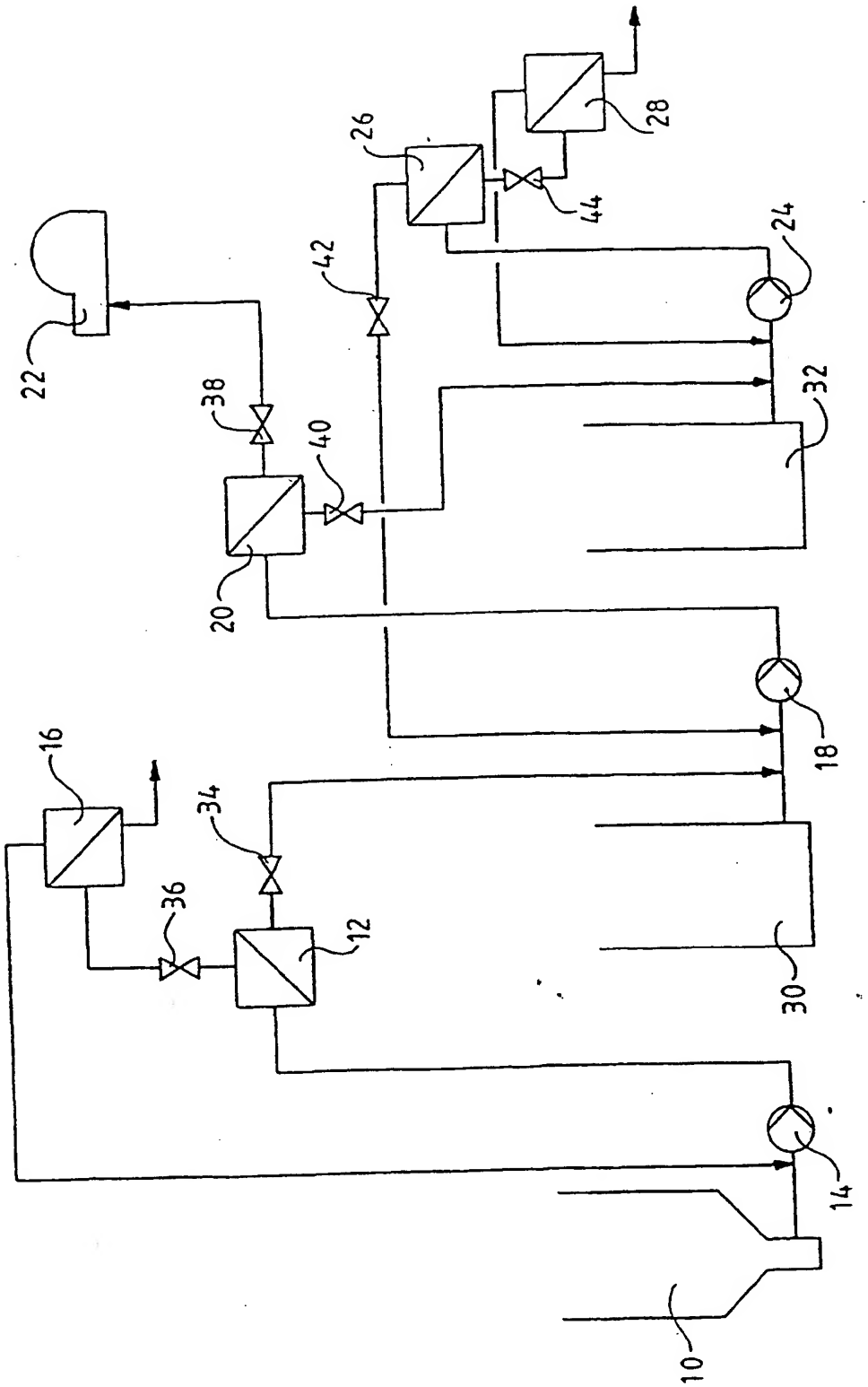

FIG. 1

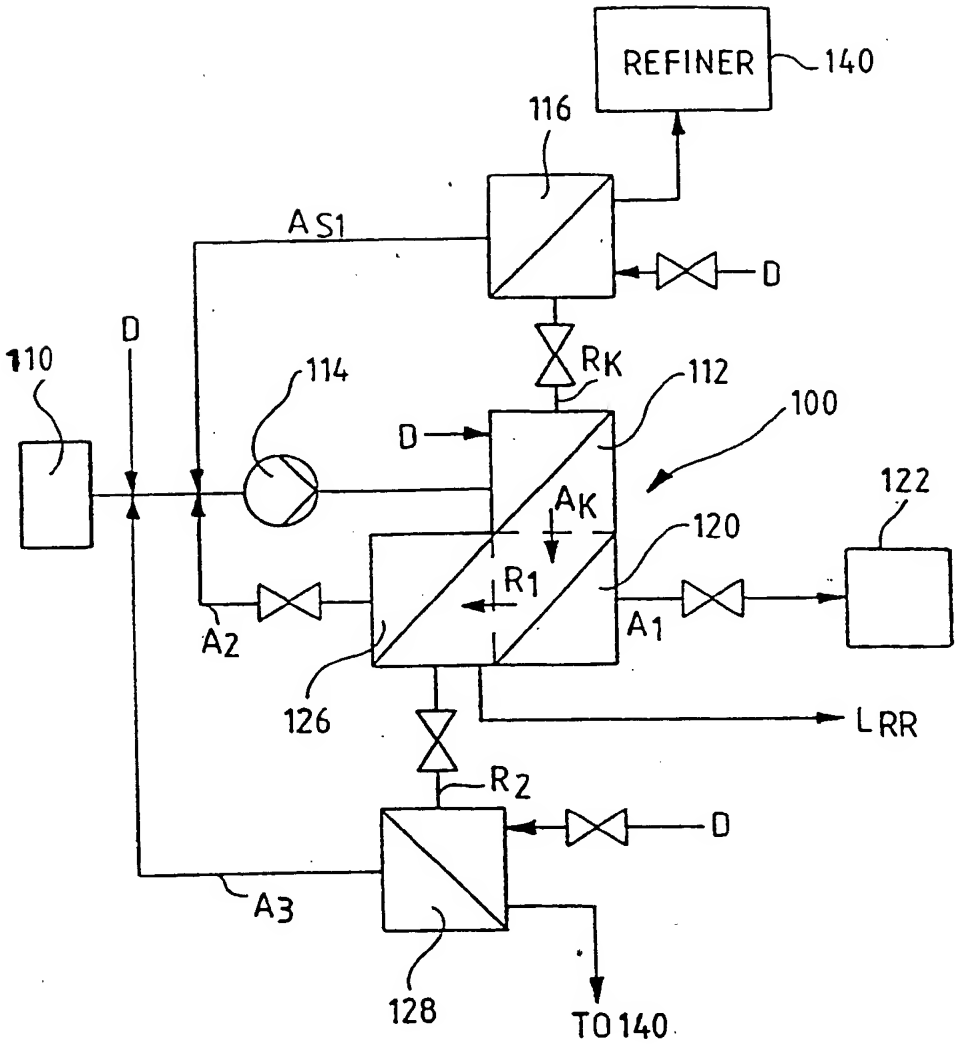

FIG. 2

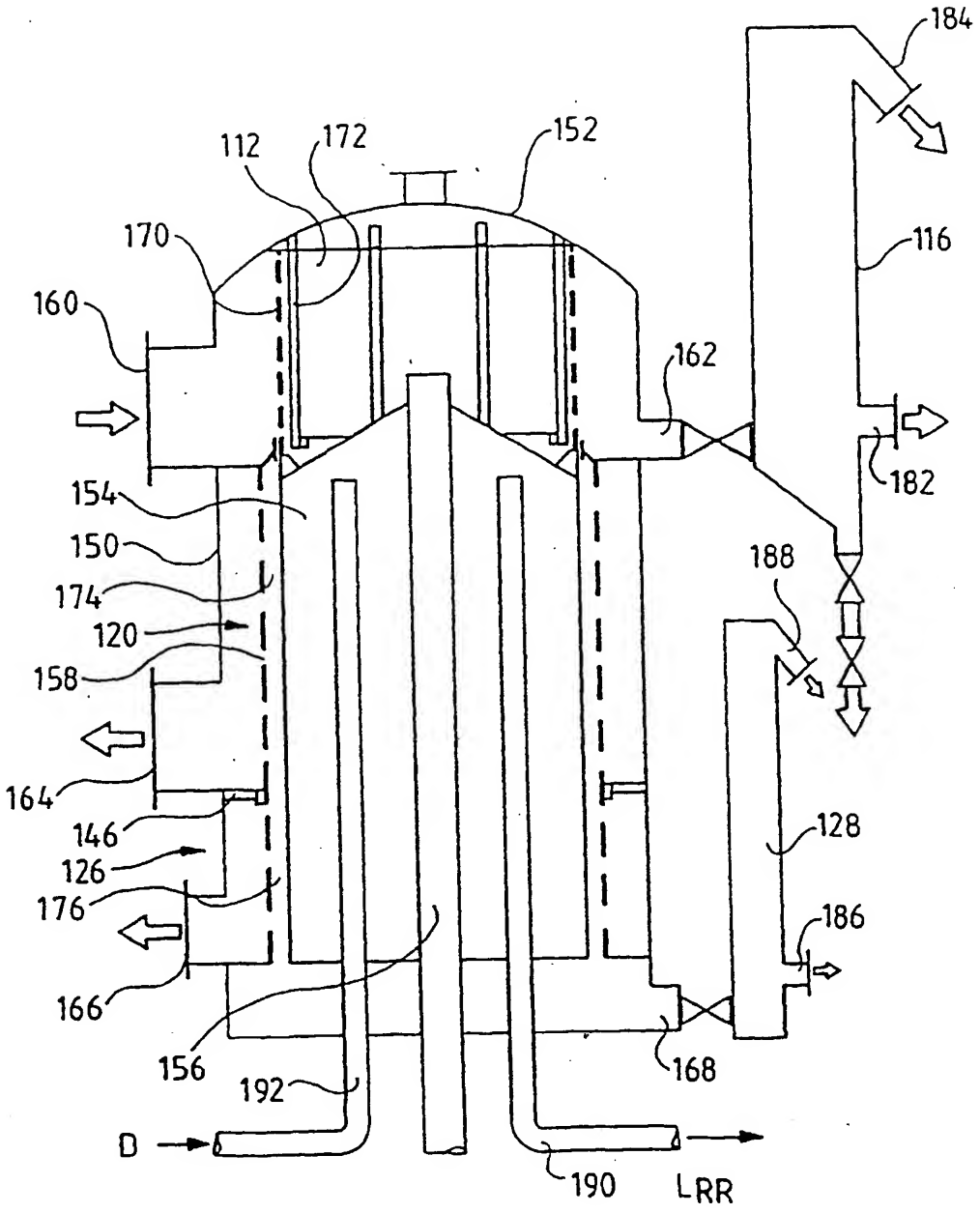

FIG. 3

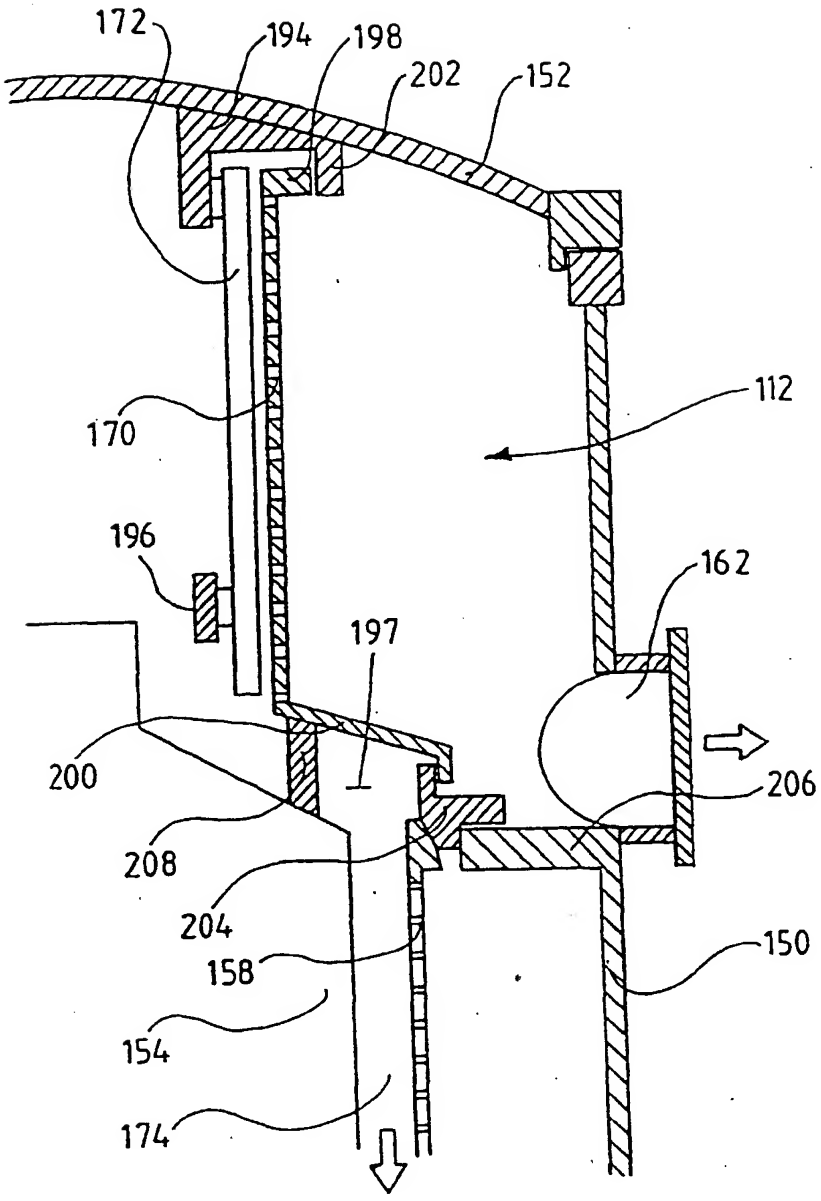

FIG. 4

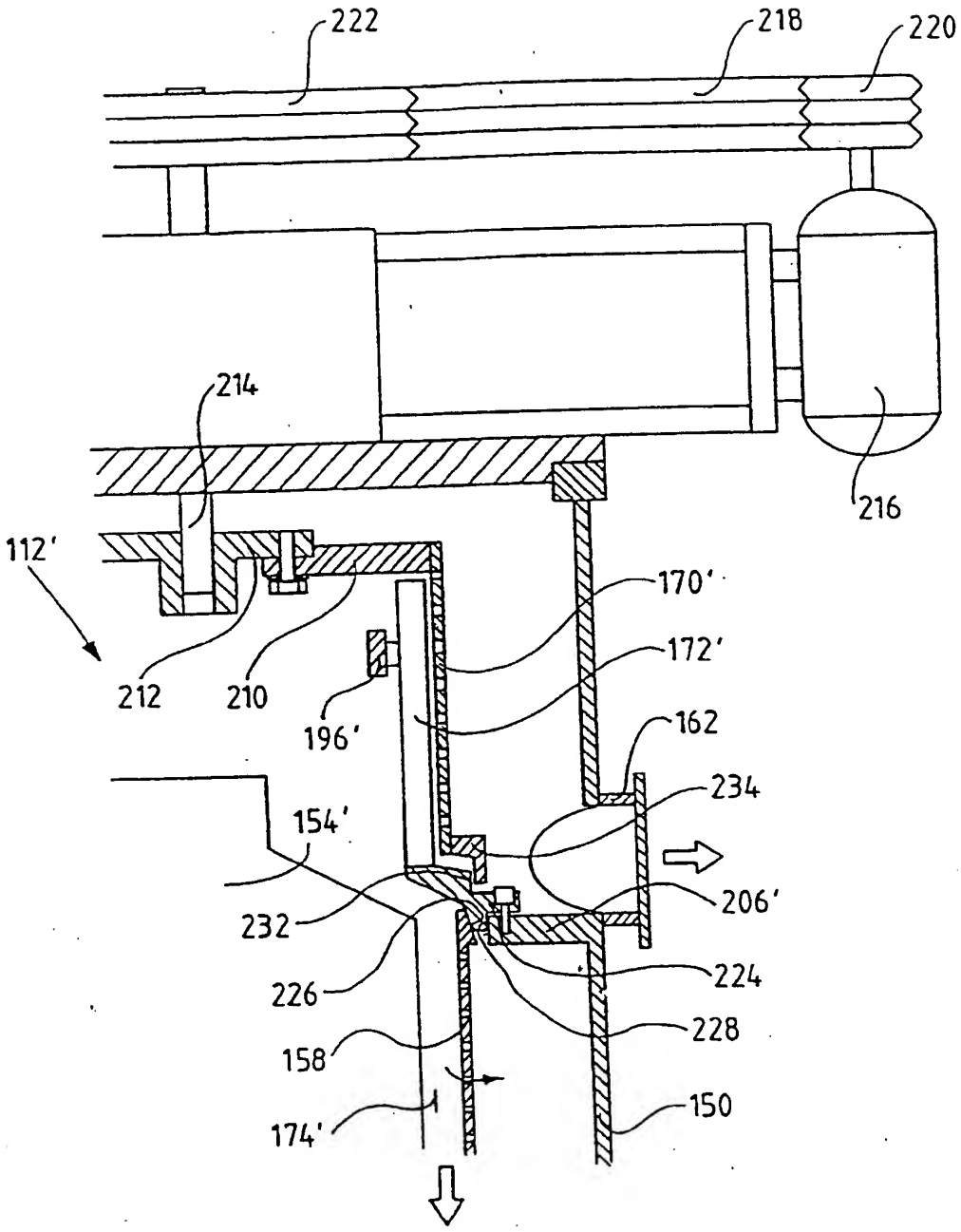

FIG. 5

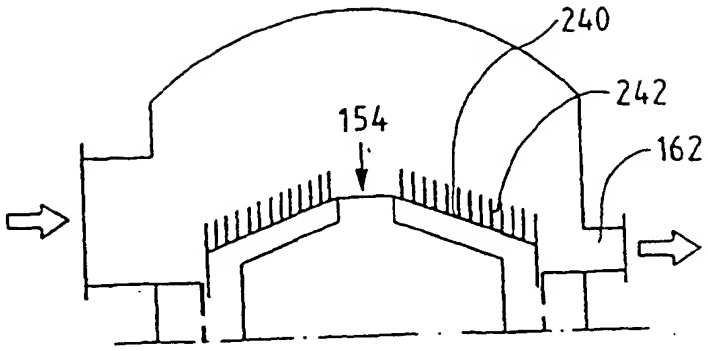

FIG. 6

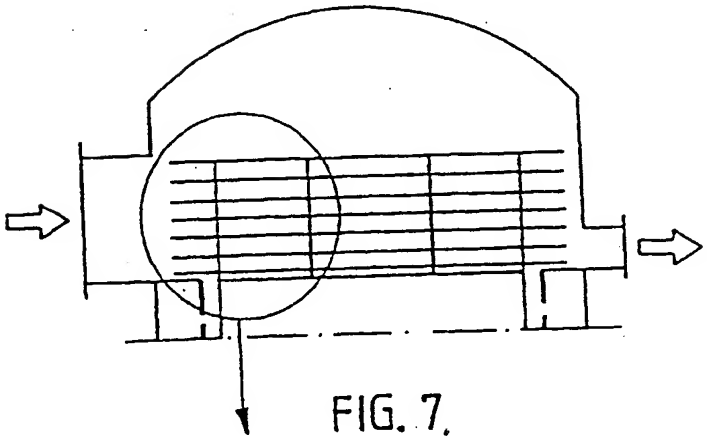

FIG. 7.

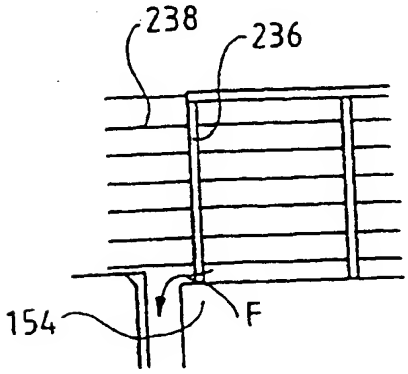

FIG. 7a

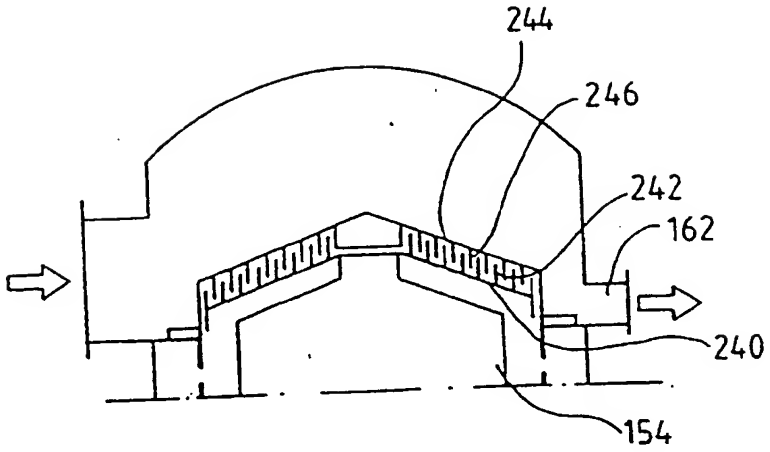

FIG. 8a

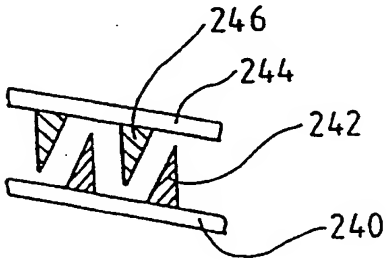

FIG. 8b

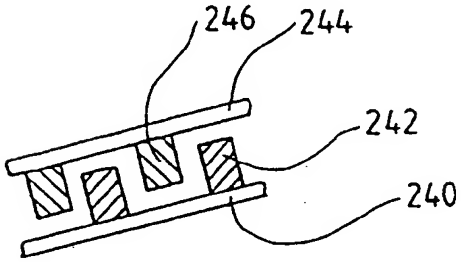

FIG. 8c

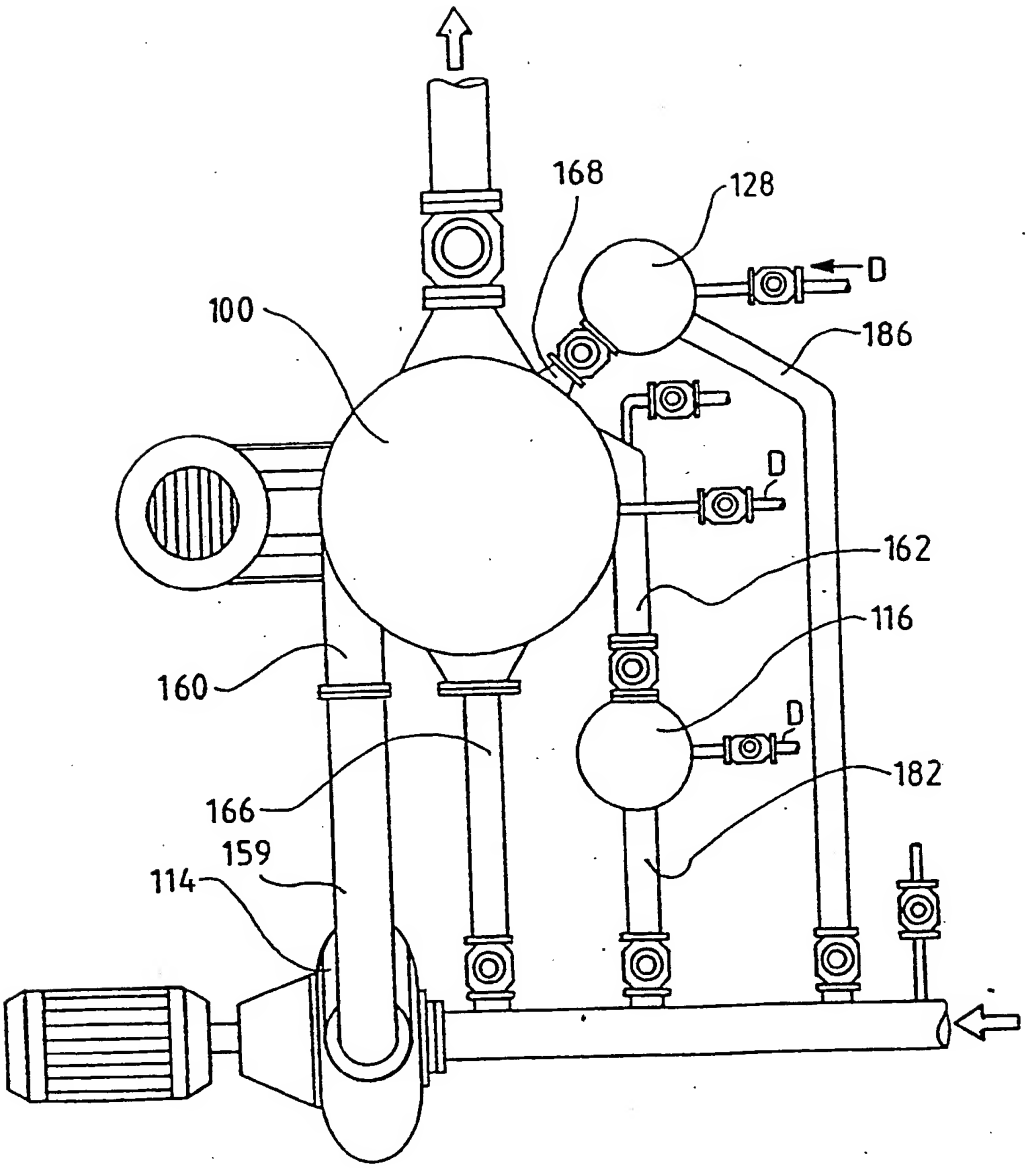

FIG. 9

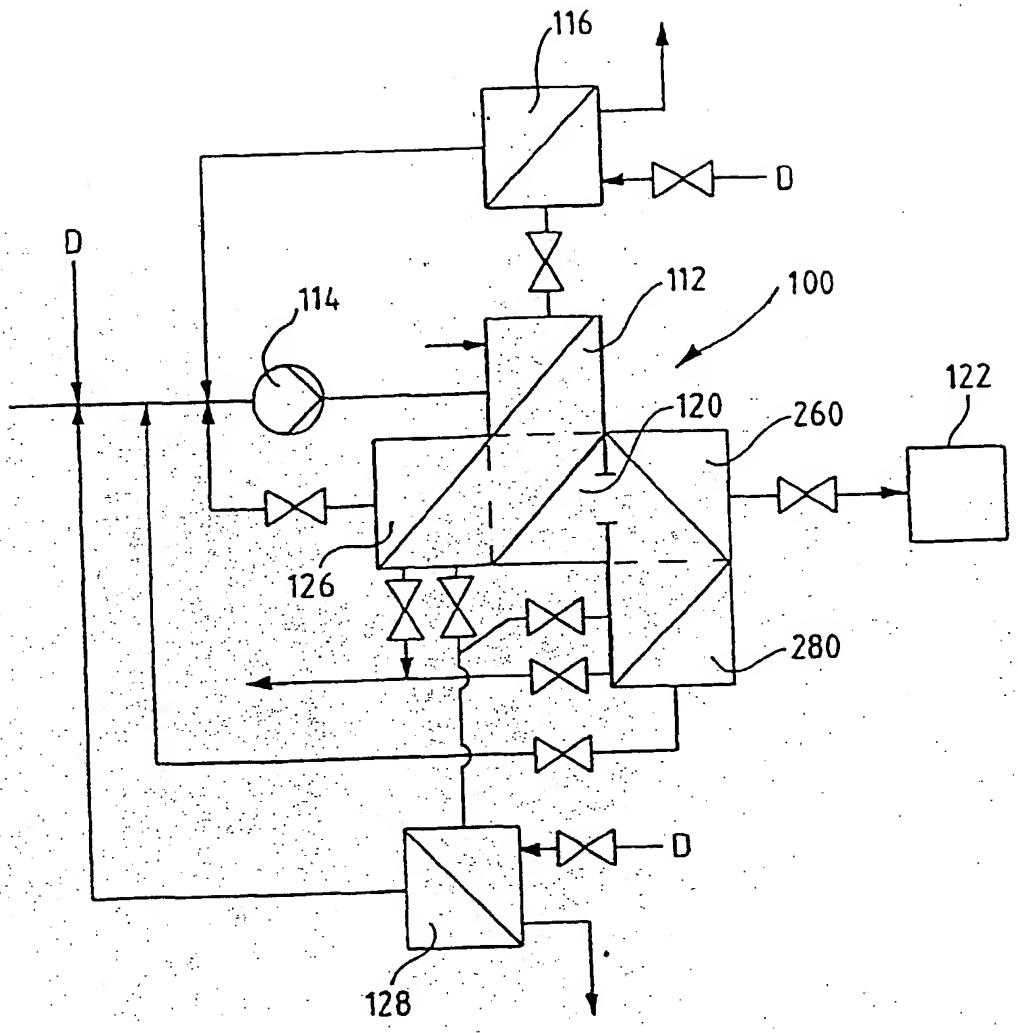

FIG. 10

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(54) Method and apparatus for screening fibrous suspension

(57) A fiber suspension, such as in a pulp mill, is treated in a manner which minimizes both the investment and the operating costs associated with a screening plant. A single pump (114) has an outlet connected to a knotter (112) and primary (120) and secondary (126) screening stages, so that the pump provides substantially the sole motive force to the pulp, moving it through the knotter and screening stages. The knotter and screening stages are provided in a common housing with the coarse screen vertically above the screening stages, and the screening stages one above the other. A single motor may be provided to rotate rotatable elements associated with the knotter and screening stages. The coarse screen may be connected to a knot washer (116) external of the housing by a valved conduit less than two meters in length, and the secondary screening stage can be connected to a tertiary screening stage (128) exterior of the housing by a valved conduit less than two meters long. Rejects from the knot wash r and secondary screening stage may be recycled to the pulp inlet, and the dilution water may be introduced where necessary.

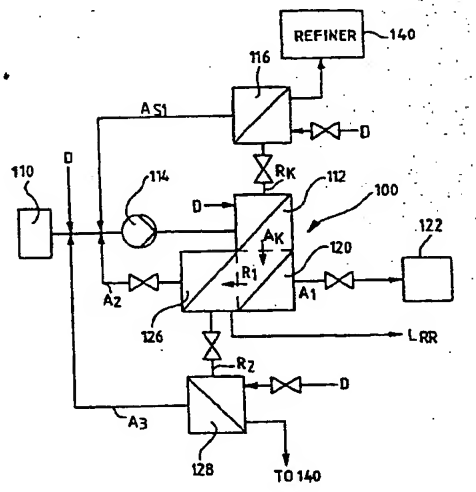

FIG. 2

EP 0 955 406 A3

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EUROPEAN SEARCH REPORT

Application Number
EP 99 11 4121

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A	* column 2, line 42 - line 49 * * column 6, line 57 - column 7, line 26; figure 7 *	11,16,17	
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D21D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	14 September 1999	Helpiö, T.

CATEGORY OF CITED DOCUMENTS

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 99 11 4121

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